tech briefs

Westinghouse Savannah River Company

SonoBeamer™ Device

at a glance

- Designed for large volume use
- Channels acoustic energy
- Increases energy density
- Emits directional sound waves
- U.S. Patent 6,489,707

for more information

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A focused beam of amplified, coherent sound waves

Scientists at Westinghouse Savannah River Company (WSRC) have demonstrated a new concept of a "sound laser" by creating a highly concentrated beam of ultrasonic waves. The SonoBeamer device concentrates acoustic energy and emits it as a narrow beam of single frequency sound waves.

Background

In recent years, theoretical attention has been paid to the physics of sound amplification by stimulated emission of radiation (SASER). The SASER is the sound analog of a free electron laser, the concept being that the propagation of a sound beam inside a resonant chamber can be constrained to produce a coherent beam of sound waves. The SonoBeamer device is the first known demonstration of the SASER principle.

At the Savannah River Site in Aiken, S.C., solidified residues in aging high-level waste storage tanks need to be dissolved before the tanks can be taken out of commission. The SonoBeamer device was originally conceived to break up these so-called "clinkers," or " heels."

The SonoBeamer concept is not unlike the well-known use of ultrasonics to break up kidney stones. In this medical application, negative pressure pulses, inducing cavitation, provide the mechanism for breaking kidney stones up in small particles.

Current ultrasonic methods are limited

Current uses of ultrasound to break up, or separate, constituents within a container require the acoustic waves to be propagated throughout the entire container. The generation of omnidirectional radial waves uselessly dissipates energy. This method is limited to relatively small containers, as its use in larger volumes would require prohibitive amounts of energy.

Also, ordinary flat plate ultrasonic transducers are limited to an energy density of a few watts/cm^2. The SonoBeamer has the potential for increasing this by an order of magnitude or more.

SonoBeamer is highly directional

The SonoBeamer is capable of emitting concentrated pressure waves at a single frequency, providing an efficient means of projecting directional sound waves into and through a medium. The directed beam can induce cavitation within a medium along a specified path or at a specific location.

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SonoBeamer™ Device

Entire device can be immersed

The SonoBeamer comprises a tube enclosed in a housing with one end open and the other end closed by an acoustically reflective wall. The tube is filled with an active medium. The housing is designed to be totally immersed in any medium through which acoustic energy is to be transmitted. If the active medium inside the tube needs to be different than the surrounding medium, the open end of the tube can be covered with a thin, acoustically transparent diaphragm.

Transducer oscillates radially

The tube, or transducer, is constructed to resonate at a desired frequency. A power source supplies a tuned, high frequency current through wires connected to the inner and outer surfaces of the tube. The current causes the tube to oscillate in a radial direction. This oscillation creates pressure waves in the active medium that propagate toward and away from the center of the tube.

Bubbles bunch at antinodes

Current from another power source flows through an electrode running down the center of the tube. This current hydrolyzes the active medium, producing bubbles that act as scattering nuclei. The radially directed waves created in the active medium by the transducer subject the bubbles to an acoustic radiation force. If the forcing frequency is lower than the resonance frequency of the bubbles, as is the case with small bubbles, the radiation force drives the bubbles toward the pressure antinodes. The fluctuating pressure waves also cause the bubbles to contract and expand. On expansion, the bubbles emit waves in all directions, generating a wave in the axial direction.

Axial beam is concentrated

By ensuring that the radial waves inside the tube are in phase and the bubbles gather at the antinodes of the axial wave, the axial wave will undergo constructive addition. The result is a concentrated, coherent axial beam.

Scattering nuclei may comprise any substance that is compressible. In addition to air bubbles, hollow microspheres or particles such as plastic powder can be used.

Other design features include controlling bubble size and uniformity, minimizing coalescence, and maintaining even distribution in the vicinity of the antinodes.

Tests confirm principle

A proof-of-principle SonoBeamer was assembled at the Savannah River Site. Four 2-inch diameter, lead-zirconate-titanate, piezoceramic cylinders were glued end-to-end to form a single, 6-inch long, radially vibrating transducer. The total length of 6 inches corresponds to two wavelengths for sound waves in water at a frequency of 19,700 Hz, which is close to the unloaded natural frequency of the 2-inch diameter cylinders. Other test hardware included a high frequency (0-20 kHz) power amplifier and pressure instrumentation.

The SonoBeamer was tested using solid plastic particles in the 5-30 micron range, 60 micron hollow phenolic microspheres, and hydrogen bubbles. Coherent wave amplification was achieved with the phenolic microspheres and with the hydrogen bubbles. Although the tests confirmed the principle of the SonoBeamer, additional development work is needed to find a more optimum microsphere and to maximize control of the hydrogen bubbles.

Partnering opportunity

Patent 6,489,707 has been issued by the U.S. Patent and Trademark Office for the SonoBeamer. The SonoBeamer should prove to be an effective device for sonochemistry applications, for cleaning of underwater structures, and for underwater communications.

WSRC invites interested companies with proven capabilities in this area of expertise to enter into a licensing agreement with WSRC to manufacture and market this device as a commercial product. Interested companies will be requested to submit a business plan setting forth company qualifications, strategies, activities, and milestones for commercializing this invention. Qualifications should include past experience at bringing similar products to market, product design and development capabilities, reasonable schedule for product launch, sufficient manufacturing capacity, established distribution networks, and evidence of sufficient financial resources for product development and launch.

Technology transfer

WSRC is the managing contractor of the Savannah River Site for the U.S. Department of Energy. WSRC scientists and engineers develop technologies designed to improve environmental quality, support international nonproliferation, dispose of legacy wastes, and provide clean energy sources.

WSRC is responsible for transferring technologies to the private sector so that these technologies may have the collateral benefit of enhancing U.S. economic competitiveness.